Dynagage™ Sap Flow Sensors

Trunk gages and stem flow gages.

Microsensors (left to right) SGA5, SGA3, SGA2.

Dynagage Summary

The Dynagage Sap Flow Sensors are the latest technology for measuring the sap flow, and thus the water consumption of plants. These energy balance sensors measure the amount of heat carried by the sap which is converted into real-time sap flow in grams or kilograms per hour. The sensors are non-intrusive and not harmful since the plants are heated up 1º C to 5º C typically. The principles of heat balance sensors are scientifically proven and references exist for most major crops and many tree species. Unlike other methods, Dynagages require no calibration since sap flux is directly determined by the energy balance and rates of heat convection by the sap flow.

The need for this new technology is great because it is an affordable and practical way to measure the water use by plants of agricultural, economic and ecological importance. Plants in greenhouses, nurseries or in natural environments can be measured with the same ease.

Dynamax introduced the first sap flow sensor prototypes in 1988 and today offers a full range of sensors from 2 mm up to 150 mm.

Microsensors 2 to 5 mm

The Dynagage Microsensors measure transpiration by small diameter crops, cereals, seedlings or floricultural species. Petiole and peduncle sap flow measurements are now possible.

Features

- **Durable acrylic shell, patented hinged clam-shell design**
- **Flexible inner core conforms to stem shape**
- **Very low power 0.07 W**

Stem Gages 9 to 32 mm

Features

- **Direct transpiration measurement**
- **Strap-on sensor collar**
- **Non-invasive and flexible**
- **Constant heat-energy balance**
- **Real-time monitoring and recording**
- **1 year warranty**

Benefits

- **Absolute measurement and no calibration required**
- **Reusable and portable**
- **Harmless and conforms to plant size**
- **Reliable and proven method**
- **Measures absolute mass-flow**
- **Helps correct decision making**

Dynamax

Dynagage™ Specifications

Trunk Gages 32 to 125 mm

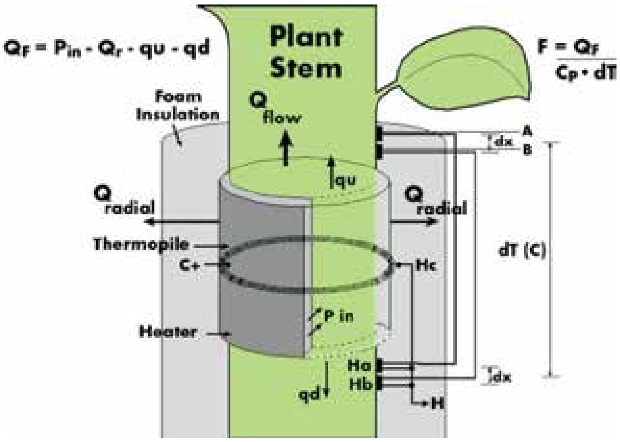
Trunk gages are unique tools for the measurement of sap flow in trees. A myriad of applications are solved by knowing tree water usage. Trunk flow gages have advanced designs that combine all temperature signals into three signal outputs and a heater voltage sensing output compatible with all other Dynagage signal connections.

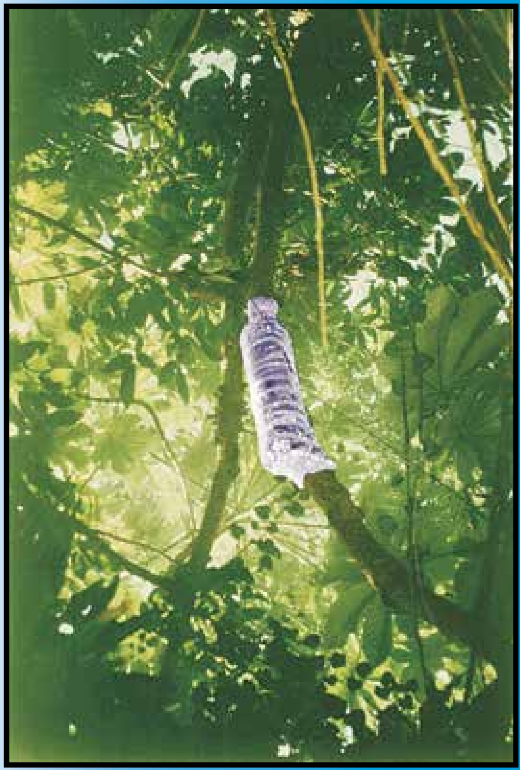
Trunk gages have four or eight pairs of differential temperature sensors spaced around the circumference of the trunk, as shown in the chart below. This advanced design ensures that flow rates that vary around the circumference are accurately monitored and averaged into one reading. Up to 18 radial heat flux sensing thermocouples are also spaced evenly around the circumference to ensure that radial heat is accurately monitored.

With the capability to monitor sap flow in tree branches, important canopy studies can be performed. Water conductivity and tree transpiration may be partitioned into the flow rates related to the canopy level.

Dynagage Summary

Model No.	Diameter Min. (mm)	Diameter Max. (mm)	Ht. (mm)	Input Volts	Typical Power (w)	No TC Pairs	TCGap dx (mm)
Microsensors							
SGA2-WS	2.1	3.5	35	2.3	.05	1	0
SGA3-WS	2.7	4	35	2.3	.05	1	0
SGA5-WS	5	7	35	4.0	.08	2	3
Stem gages							
SGB9-WS	8	12	70	4.0	.10	2	4
SGA10-WS	9	13	70	4.0	.10	2	4
SGA13-WS	12	16	70	4.0	.15	2	4
SGB16-WS	15	19	70	4.5	.20	2	5
SGB19-WS	18	23	130	4.5	.30	2	5
SGB25-WS	24	32	110	4.5	.50	2	7
Trunk gages							
SGB35-WS	32	45	255	6.0	.90	4	10
SGB50-WS	45	65	305	6.0	1.4	8	10
SGA70-WS	65	90	410	6.0	1.6	8	13
SGA100-WS	100	125	460	8.5	4.0	8	15
SGA150-WS	150	165	900	9	13	8	20





Tree-trunk gages applied to rain forest research inside the Biosphere II dome in Oracle, Arizona. Picture by permission of Biosphere II.

Energy Balance Equations

The energy balance is:

$P_{in} = Q_r + Q_v + Q_f$ (W) (1)

$P_{in} = V^2/R$ (W) from Ohm's law

Vertical conduction components are:

$Q_v = Q_u + Q_d$ (2)

$Q_u = K_{ST}\, A\, dTd/dx$

$Q_d = K_{ST}\, A\, dTd/dx$

Kst = stem thermal conductivity (W/m x °K)
A = stem area (m^2)
dTu/dx = temperature gradient (°C/m)
dx = thermocouple junction spacing (m)

$Q_r = K_{sh} \times CH$ (3)

K_{sh} = sheath conductance (W/mV)

K_{sh} is determined by solving equation (1) during zero-flow, $Q_f = 0$:

$K_{sh} = (P_{in} - Q_v)/CH$ (W/mV) (4)

CH = radial-heat thermopile voltage (mV)

Finally:

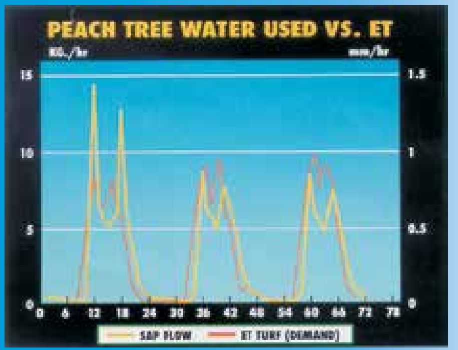
$F = (P_{in} - Q_v - Q_r)/Cp \times dT$ (g/s) (5)

Cp = specific heat of water (J/g x °C)
dT = temperature increase of sap (°C)
dT = (AH = BH) /2 (°C)

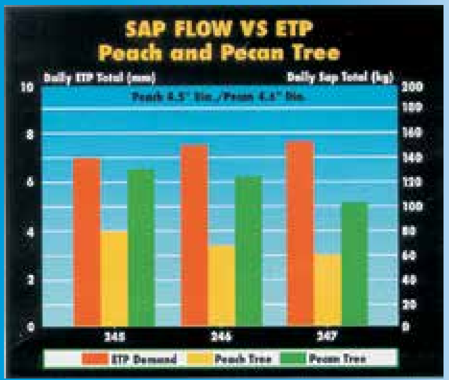
Dynamax

Dynagage™ Applications

SGA5 microsensor, with weather shield, monitors okra plant transpiration.



Comparing peach tree hourly transpiration to evapotranspiration demand computed from Penman-Van Bavel modeling software and Dynamet Weather Station.



Peach and pecan tree accumulated daily water consumption declines 25 and 20% under limited water availability as ETP demand increases.

Dynagage Applications

Agricultural Engineer
Agricultural Consultant
Botanist
Citrus Grower
Crop Science
Crop Physiology
Entemology
Extension Service
Farm Industry
Fertilizer Evaluation
Genetic Engineering
Global Climate Change
Greenhouse Control
Forestry Planning
Horticulture
Hydrology
Irrigation Systems
Orchard Monitor
Ornamentals
Plant Physiologist
Phytoremediation
Pollution Studies
Pomology
Reforestation
River Water Authority
Seed Genetics
Tree Farm
Weed Science
Water Conservation
Xeriscape Plant Selection

Dynagage sensors work well with most of the worlds major crops and trees. Vines, shrubs, natural vegetation, and ornamentals can also be monitored with the Dynagage Sap Flow System.

Species Monitored by Dynagage

Crops

Cucumber
Cotton
Corn
Sorghum
Soybean
Sugarcane
Sunflower
Sweet Potato
Tomato
Wheat

Tree

Almond
Apple
Avocado
Bald Cypress
Douglas Fir
Eucalyptus
Ficus
Kumquat
Mangosteen
Oak
Orange
Pecan
Pine - Xmas Tree
Pine - Lobolly
Poplar
Red Cedar
Tangerine

Other

Coffee
Grape
Kiwi
Ligustrum
Mesquite
Potato
Rose

Dynamax Inc
10808 Fallstone Rd #350
Houston, TX 77099 USA
Tel: 281-564-5100 Fax: 281-564-5200
admin@dynamax.com
www.dynamax.com

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